Further Experiments with Lok-Test and Ultrasonic Test in Relation to Fresh and Hardened Concrete

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FURTHER EXPERIMENTS WITH LOK-TEST AND ULTRASONIC TEST IN RELATION TO FRESH AND HARDENED CONCRETE

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Introduction

Lok-test is mainly a non-destructive pull-out test for determination of concrete strength. The method is described in (1) and it is detailed discussed in theory (2). The method is welknown in practice. Ultrasonic is commonly used for investigations of several materials, especially concrete.

In a project (3) about non-destructive testing of concrete different methods and the relations to concrete are discussed in theory and practice. This paper point out some interesting results from further experiments in this area.

Lok-test versus splitting strength

In the normal lok-test procedure test bolts are placed in the concrete before casting. The bolt is pulled out of the concrete with a counter-pressure member with a diameter 55 mm, which is calculated to give a compressive fracture, figure 1. Increasing the diameter of the counter-pressure member will change the condition of fracture.

The diameter of the member used in these experiments is 162 mm, figure 2 D, and when the test bolt is pulled out the pull-out force is more related to the tensile strength of the concrete. Some experiments have been done to investigate this. Concrete of different compressive strengths have been casted in 15/30 cm cylinders and 20 cm cubes with test bolts. Compressive strengths σ_c and splitting strengths σ_{sp} have been determined at the cylinders and test bolts have been pulled out with both counter-pressure members. The two pull-out forces in kN are indicated L_L (normal) and S_L.

In the compressive strength interval

$$5\ MN/m^2 < \sigma_c < 50\ MN/m^2$$

and the splitting strength interval

$$0{,}5\ MN/m^2 < \sigma_{sp} < 4{,}5\ MN/m^2$$

following »formulas» have been found with the indicated coefficient of correlation

$$L_L = 0{,}92 \cdot \sigma_c + 0{,}03 \qquad 96\%$$

and

$$S_L = 3{,}57 \cdot \sigma_{sp} + 1{,}40 \qquad 92\%$$

It can be concluded, that lok-test can be used for determination of the splitting strength of concrete, because the rupture of the concrete is placed in the inner area of the bigger counter-part member. As expected the last formula is not so exact determined as for compressive strengths.

Secondary stresses' influence on lok-test and ultrasonic velocity

The purpose for some other experiments has been to investigate, if secondary stresses have influence on the lok-test strength and the ultrasonic velocity. Cylinders and cubes with test bolts have been casted as mentioned before of concrete with different strengths, indicated by the cement/water ratios: C/W = 0,63 - 1,00 - 1,50 and 2,50. The compressive strengths of the cylinders has been determined and the cubes have been loaded with a stress of 0,5 MN/m^2. Test bolts are pulled out, both with the normal and the bigger counter-part. The cubes are loaded more and more and test bolts are pulled out. The compressive strength of the cubes are determined after the test bolts are pulled out.

Of the results, from figure 3, it can be noticed that for a loading up to 60-70% of the compressive strength there is only a small decrease of the pull out force L_L and S_L.

Before pulling out the test bolts the ultrasonic velocity has been determined. In figure 4 you see how the ultrasonic velocity changes by loading. The tendency as mentioned above is founded. The loading direction is perpendicular of the direction of pull-out and the ultrasonic measurement.

Early age ultrasonic velocity of concrete

With the purpose to find a method to early age determination of concrete strength, some experiments with ultrasonic velocity of concrete have been done.

The set-up is shown in figure 5, where the fresh concrete is placed in a box, with the ultrasonic heads up and down. A is the Pundit, B the add-on unit, C is a minirecorder and D is a timer. Because of the great changes in ultrasonic velocity in the first hours, it can be necessary to use a logaritmic converter before using the minirecorder.

Figure 6 shows examples of results from measurements on 4 different concretes. An analysis of regression has been done of several results of the ultrasonic velocity of 24 hours, v_{24h} and the compressive strength σ_c of 28 days and the »formula» can be written as

$$\ln \sigma_c = 1{,}8 \cdot v_{24h} - 3{,}3$$

with a coefficient of correlation = 94%. It can be concluded that measurement of the ultrasonic velocity to an early age can be related to the compressive strength at normal ages.

Concluding remarks

This paper shortly describes some further experiments and the interesting results obtained with two non-destructive methods in relation to concrete can give a better knowledge of the properties of concrete.

Literature

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(2) Jensen, B. C. and M. W. Braestrup: Lok-test determines the compressive strength of concrete.
Nordisk Betong, 1976 : 2.

(3) Jensen, J. Kr. Jehrbo: Ikke-destruktiv prøvning af beton.
Report nr. 7806 (in Danish), Aalborg University Centre, 1978.

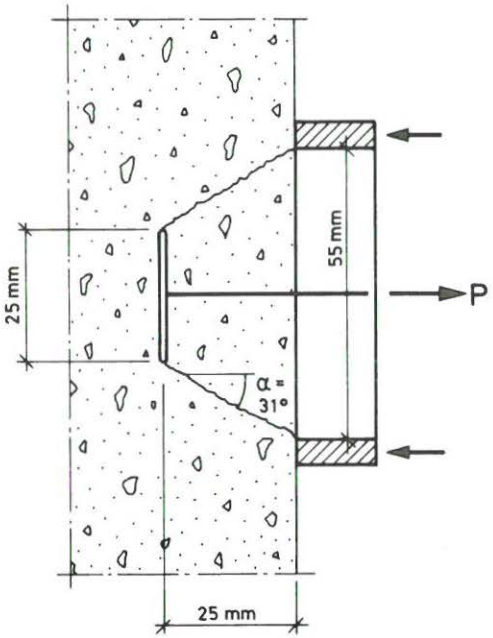

Figure 1: Lok-test sketch.

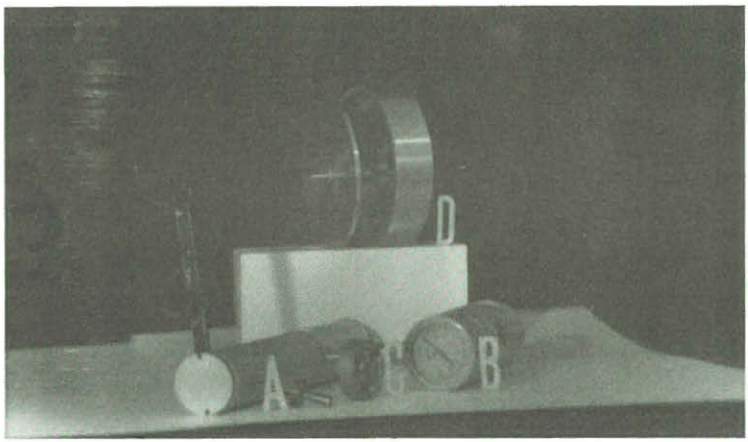

Figure 2: Lok-test equipment.

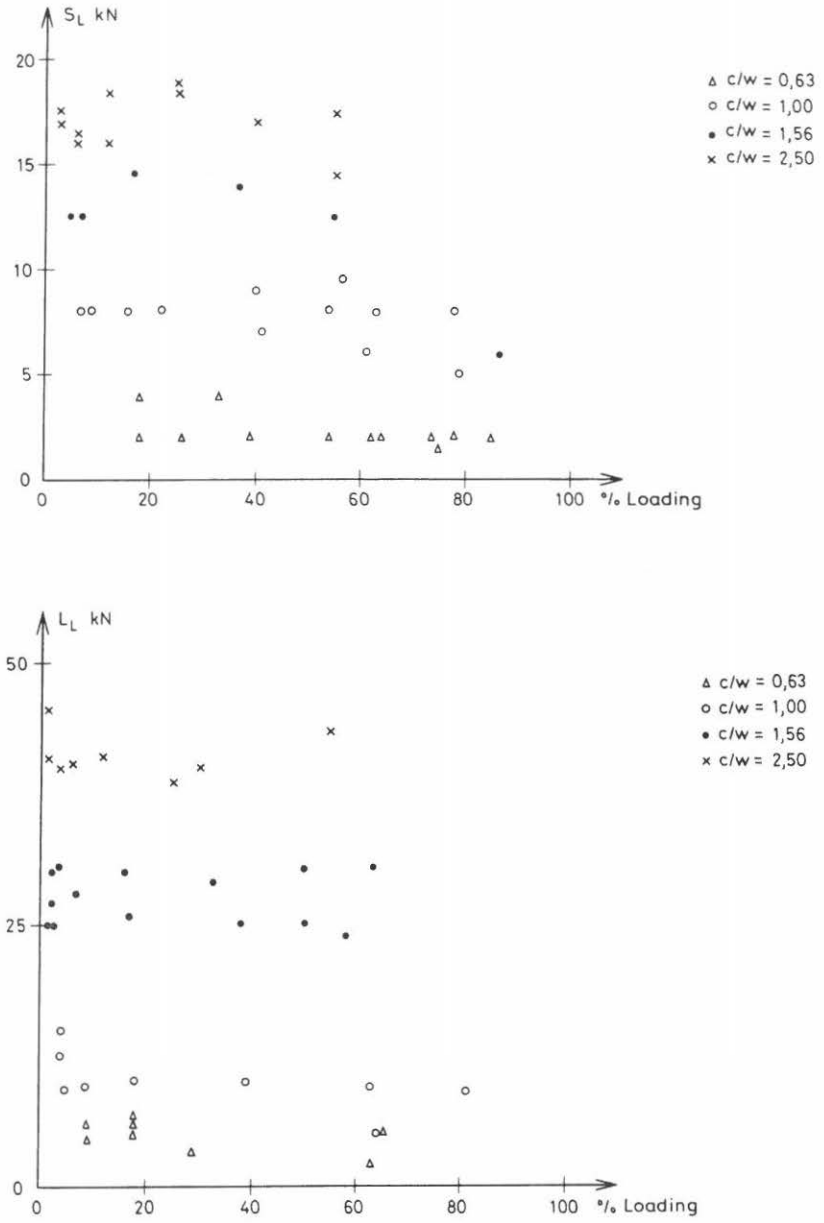

Figure 3: Pull-out forces versus loading.

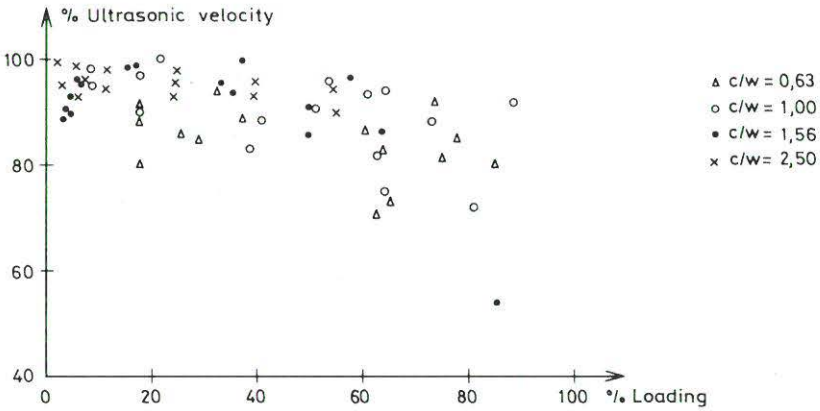

Figure 4: Ultrasonic velocity (%) versus loading.

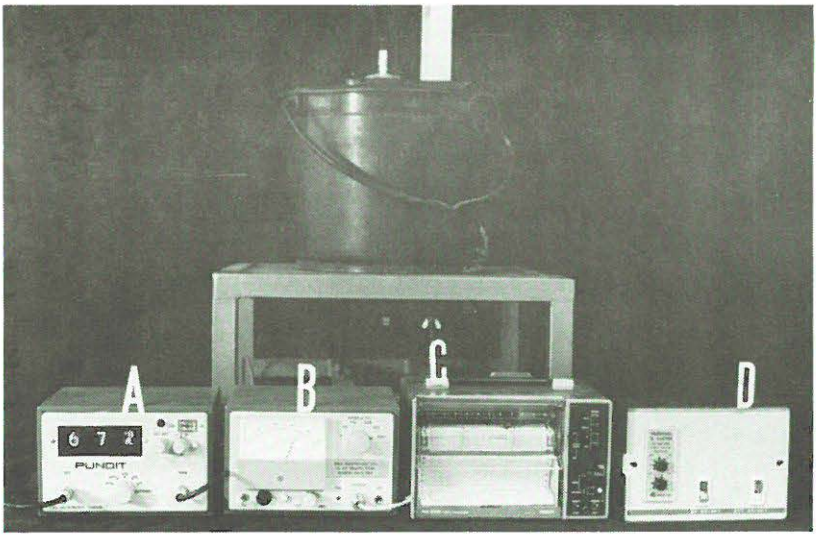

Figure 5: Early age measurement of velocity.

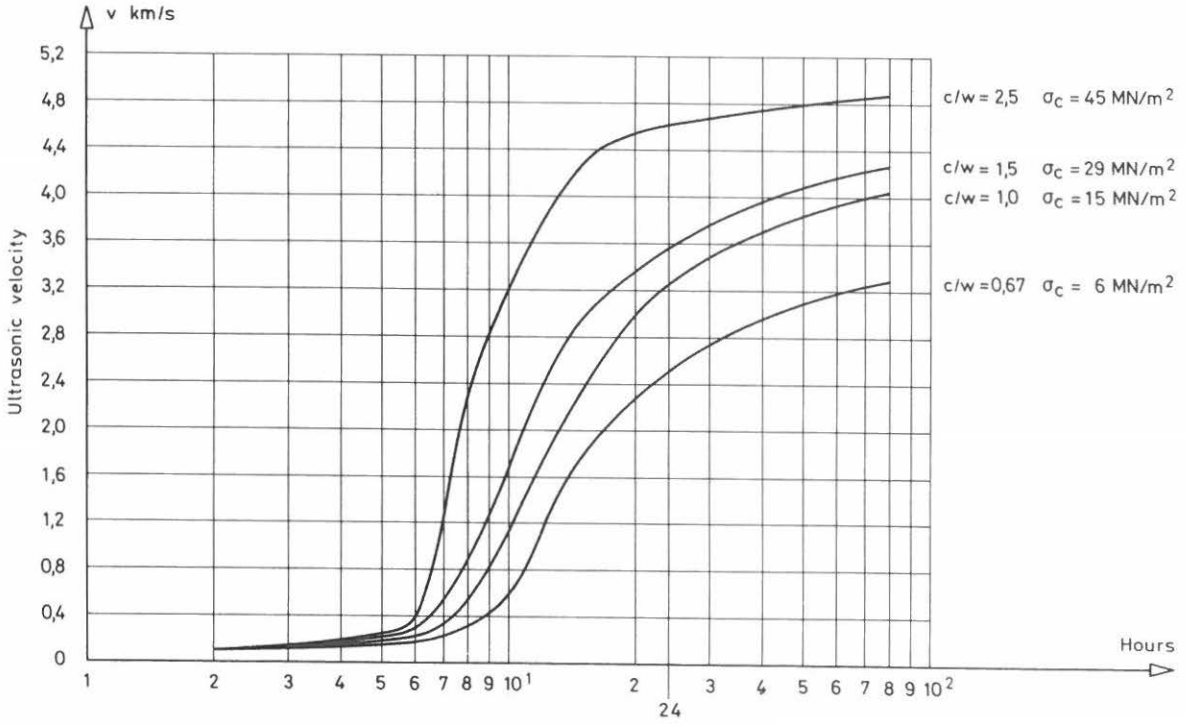

Figure 6: Ultrasonic velocity versus time.